DOCUMENT RESUME

ED 307 982 PS 018 032

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TITLE How Two-Year-Olds Use Forward Search Strategy To Solve Problems.
PUB DATE Apr 89
NOTE 13p.; Paper presented at the Biennial Meeting of the Society for Research in Child Development (Kansas City, MO, April 27-30, 1989).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Cognitive Ability; Foreign Countries; *Infant Behavior; *Problem Solving
IDENTIFIERS Great Britain; *Strategic Behavior

ABSTRACT

The ability of 2-year-olds to carry out a forward search strategy was examined in a study of performance on platform rotation problems. One group of children was tested successively on two analogous versions of a task. The two versions shared the same underlying principle but had different surface characteristics. A control group was given an unrelated problem, and was then tested on the platform rotation tasks. Findings showed that 2-year-olds were able to use a sophisticated forward search strategy in which simple methods were attempted first and more complex methods later. Children rejected inappropriate methods from further consideration. The ability to inhibit errors was related to the type of method which had been attempted. The problems were solved in one trial, and there was direct transfer across the different types of platform rotation tasks. Four figures are attached. (RH)

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HOW TWO-YEAR-OLDS USE FORWARD SEARCH STRATEGY TO SOLVE PROBLEMS

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Poster presented at the Biennial Meeting of the Society for Research in Child Development, Kansas City, Missouri, April, 1989.

Running Head: Forward search

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ABSTRACT

The ability of 2-year-olds to carry out a forward search strategy was examined in a study of performance on platform rotation problems. One group of children was tested successively on two analagous versions of a task sharing the same underlying principle but with different surface characteristics. A control group was first given an unrelated problem, and subsequently tested on the platform rotation tasks. Children structured their sequence of attempts by starting with simple methods and later progressing to more complex ones. They rejected inappropriate methods from further consideration, although ability to inhibit errors was related to type of method which had been attempted. The problems were solved in one trial, and there was direct transfer across the different types of platform rotation tasks.

HOW TWO-YEAR-OLDS USE FORWARD SEARCH STRATEGY TO SOLVE PROBLEMS

Although unplanned forward search or trial-and-error methods appear early in infancy, their effectiveness can be enhanced by a number of factors which may take time to develop. First, the infant needs to carefully monitor the succession of attempts in order to remember what has been tried and the outcome. One way of assisting this monitoring might be to impose some organization on the sequence of attempts. Second, infants must be able to inhibit errors and avoid repetition of unsuccessful methods in order to make any progress. Third, infants who solve a problem should be able to incorporate the new method into their repertoire. If the solution emerged from a series of false starts and dead ends, the infant must be able to disentangle the task-relevant segments from the task-irrelevant. Failure to do so would lead to difficulty in repeating success and would rule out any possibility of transfer to other problems. Efficient application of unplanned forward search strategy therefore requires considerable skill in regulating and monitoring performance.

Little is known of the abilities of infants for using forward search to solve problems. The aim of this study was to examine the application of this type of trial-and-error strategy by 2-year-olds in order to identify some of the abilities which have developed by the end of the sensory-motor stage. The study focused on three aspects of problem solving: (a) whether children organised their search for a solution; (b) the extent to which children could inhibit failed methods; and (c) the ability of children to transfer the solution to a new task sharing the same underlying principle but differing in surface characteristics.

There were 40 children with a mean age of 26.3 months who were divided into two equal groups. Two types of platform rotation problem were used which differed in surface characteristics but shared the same underlying principle for solution. One was a rectangular lever and the other was a circular tray, both of

which rotated about a central pivot. Children had to discover how to retrieve a toy which was fastened to the far end of the platform. The transfer group received three trials with one of the tasks followed by three trials with the other. Order of presentation of tasks was counterbalanced. The control group were first given an unrelated problem in which they had to retrieve a candy from inside a transparent tube using a stick. After working on this problem, the control group received 3 trials with a platform task, one half getting the lever and one half the tray.

Methods used to solve the platform tasks (derived from descriptions provided by Koslowski and Bruner, 1972) were scored from video recordings of the trials. Nine types of attempt were identified and grouped into four categories depending on what the child was trying to achieve. The lowest level (direct approach) consisted of direct attempts (pointing at the toy, reaching for it, or trying to climb on the table). The next level (move platform) included simple methods involving contact with the platform (fiddling with the pivot screw, pulling the platform, or trying to lift it). A third level (rotate platform) included methods in which the platform was rotated (turning it to and fro, or turning it to one side), and the highest level (rotate and capture) was the use of an uninterrupted movement which rotated the platform and led to retrieval of the toy. Time taken to solve the problem was also recorded.

All children successfully retrieved the toy on every trial. The problems were effectively solved in one trial with the majority of unsuccesful attempts and longest trial times occurring on trial 1 for both groups (for the transfer group, trial 1 refers to the intial trial on the task presented first). Preliminary comparisons of scores for the transfer group on the task presented first and the control group showed no significant differences on either measure, so the data from both groups were combined.

Scores on both measures were significantly higher on trial 1 than on trials 2 and 3. Examination of the sequence of attempts on trial 1 revealed a highly significant increase in level of category during the trial. Out of a total of 25 children who produced two or more unsuccessful attempts in different categories, the majority started with the simplest (direct approach), and only later tried a method from a higher-level category (move platform or rotate platform). Results are shown in Fig. 1, and the increase in complexity from the first to the second category of attempt was significant, sign test, $p<.02$. There were 12 children who produced unsuccessful attempts from 3 different categories (Fig. 2). The majority of these started with the simplest level (direct approach), then tried an intermediate level (move platform), and finally tried a more complex method (rotate platform). There was a highly significant relation between complexity of method and order of use for these children , Page's L Test, $Z=3.47$, $p<.002$.

Overall, 10% of children solved either of the platform-rotation problems immediately on the first trial. A further 43% solved the problems after one or more unsuccessful attempts but without repeating any method. The remaining 47% also solved the problems but repeated previously tried methods. On average they required 6.7 attempts to reach the solution, of which 3.2 were repetitions of methods tried earlier. However, the likelihood that a method would be repeated was unequal across the categories. The proportion of repetitions in the 'direct approach' category (50%) was significantly higher than in the 'move platform' (36%) or 'rotate platform' (10%) categories, $\chi^2(2)=12.7$, $p<.01$.

Finally, evidence for transfer was obtained by comparing the performance of the control group with that of the transfer group on task presented second. The control group produced more unsuccessful attempts than the transfer group (Fig.3). Because there was a high proportion of zero scores, the data were examined with non-parametric factorial analyses based on ranks (Meddis, 1984).

The control group made significantly more attempts on trial 1 (mean = 4.55) than the transfer group (mean = 0.45, $\chi^2(1)=22.2$, $p<.001$. This difference remained on trial 2, (control mean = 0.55; transfer mean = 0.05), $\chi^2(1)=5.86$, $p<.025$, but there was no difference on trial 3 (control mean = 0.05; transfer mean = 0.05). There were no significant effects for task (lever and tray), or for the group×task interaction on any trial. Trial durations were examined by ANOVA with two between factors (group and task), and one within factor (trials). The control group had significantly longer trials overall (mean = 26.7 sec) than the transfer group (mean = 7.1 sec), $F(1,36)=28.2$, $p<.001$, and there was a significant trial×group interaction, $F(2,72)=24.0$, $p<.001$, (Fig.4). The mean trial durations for the control group for trials 1, 2, and 3 were 65.0 sec, 8.0 sec, and 7.0 sec respectively. The mean trial durations for the transfer group for trials 1, 2, and 3 were 9.2 sec, 6.2 sec, and 6.1 sec. The source of the interaction was the massive difference in trial duration which occurred on trial 1. A significant effect was also found for the tasks with longer trials occurring with lever problems (mean = 21.2) than with tray problems (mean = 12.6), but none of the interactions with task was significant.

These findings show that 2-year-olds are able to perform a sophisticated forward search strategy in which simple methods are attempted first and more complex methods only later. Forward search structured in this way might ease the load on memory required for monitoring progress to a solution. By grouping attempts into categories and trying out methods in one category before proceeding to the next, the child need only remember which categories have been attempted instead of all the individual methods. In addition, the regular shift in level of attempt indicates that children were able to inhibit errors and try out new methods. Less than half the children repeated attempts, and the fact that the proportion of repetitions varied with the category of attempt rules out

forgetting or general failure to inhibit errors as an explanation. If children repeated failed methods because they were unable to remember which had already been tried or could not inhibit errors, then the proportion of repetitions should have been equal across all categories. One reason why 2-year-olds continue to try a direct approach may be that they see it as a method which could work if executed properly. Lifting or pulling the platform clearly will not work if the platform fails to move, but a direct reach might if the infant tried a bit harder. Such a basis for the different level of repetitions would indicate a subtle appreciation by young children of the reason for failure.

The clear differences in performance of the groups showed that considerable transfer occurred between the tasks. Children who had learned to solve one of the tasks showed an immediate and direct transfer when the task was changed, and performance was markedly superior to infants in the control group who were attempting the tasks for the first time. The rapid learning in one trial and transfer between different versions of the problem indicate that children had successfully distinguished those components of their solution which were relevant to attainment of the goal from those which were not.

Piaget (1953) argued that problem-solving improves in the second year through the use of strategies based on representation or planning. His view was that children begin to invent new means for solving tasks through mental combination, with the result that problem solving becomes more effective and more efficient. However, Piaget's evidence for the development of methods based on planning in the final stage of infancy is weak and his observations are ambiguous (Willatts, 1989; in press). An alternative explanation for the improvement in problem solving is that children engage in more effective forward search as a result of changes in monitoring performance, error-inhibition, and transfer. The findings of the present study demonstrate these aspects of

forward search in the problem solving of 2-year-olds, and it remains for future research to explore their development during the second year.

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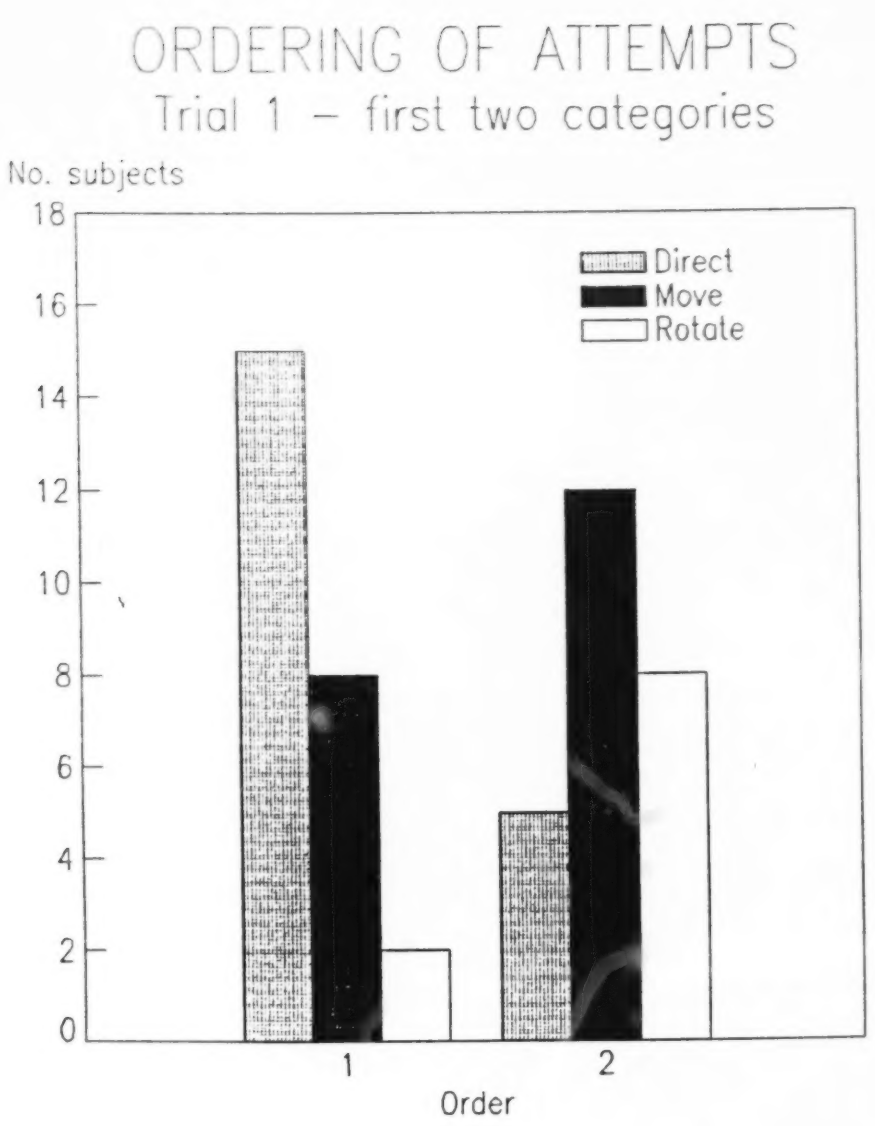

Fig. 1: Complexity of attempt and order of use for children in both groups who produced attempts in at least two different categories on very first trial.

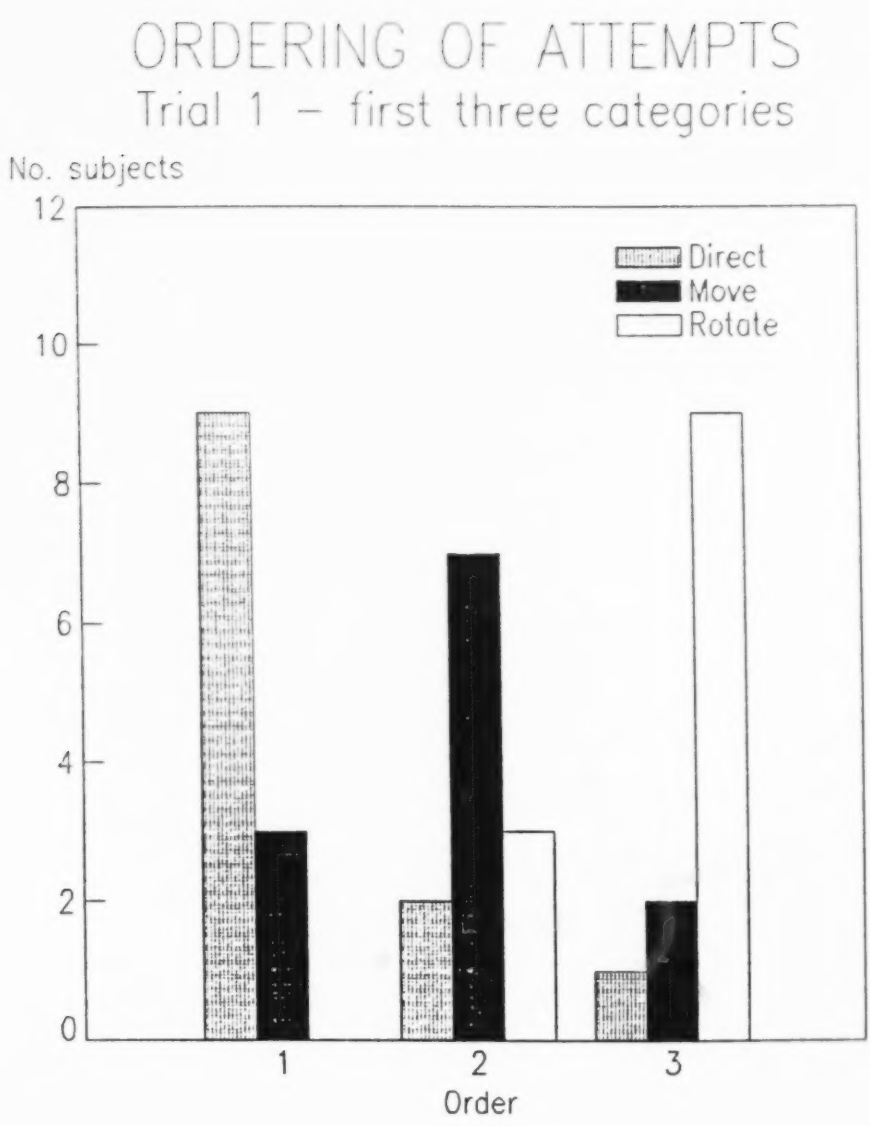

Fig. 2: Complexity of attempt and order of use for children in both groups who produced attempts in three different categories on very first trial.

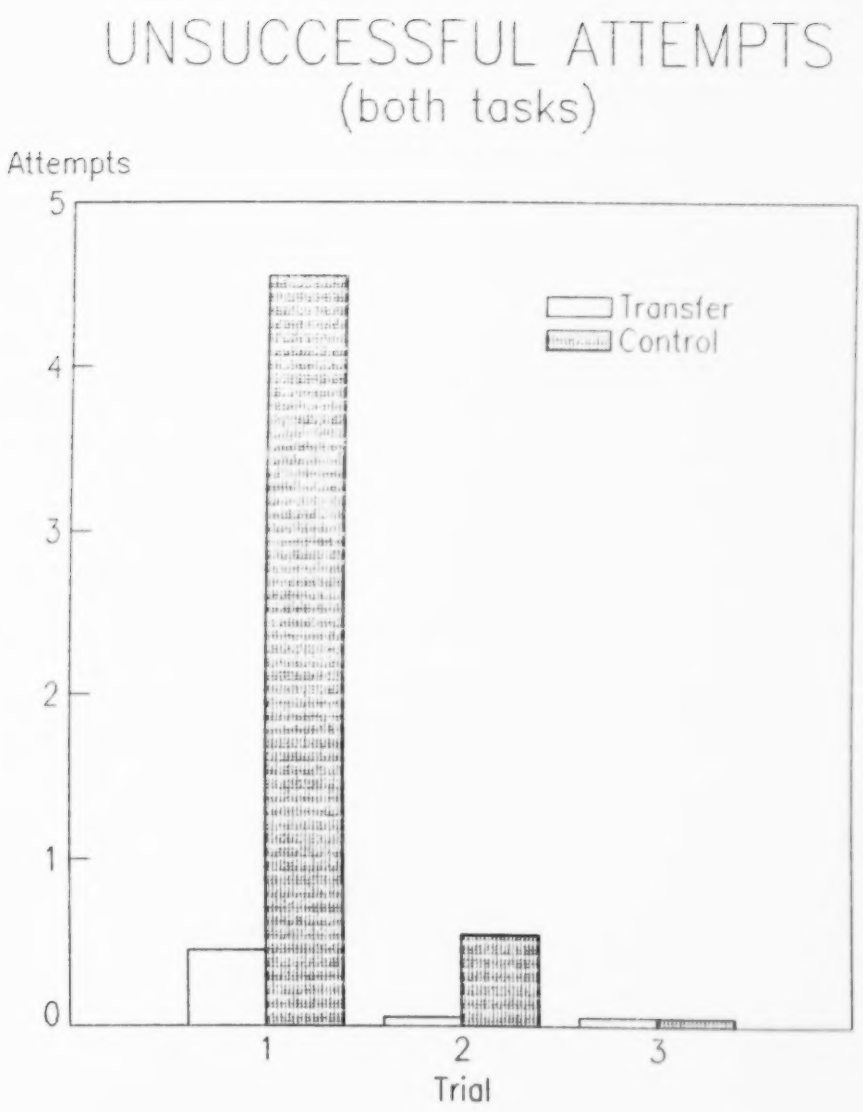

Fig. 3: Mean number of unsuccessful attempts produced by children in transfer and control groups over three trials for both platform rotation tasks.

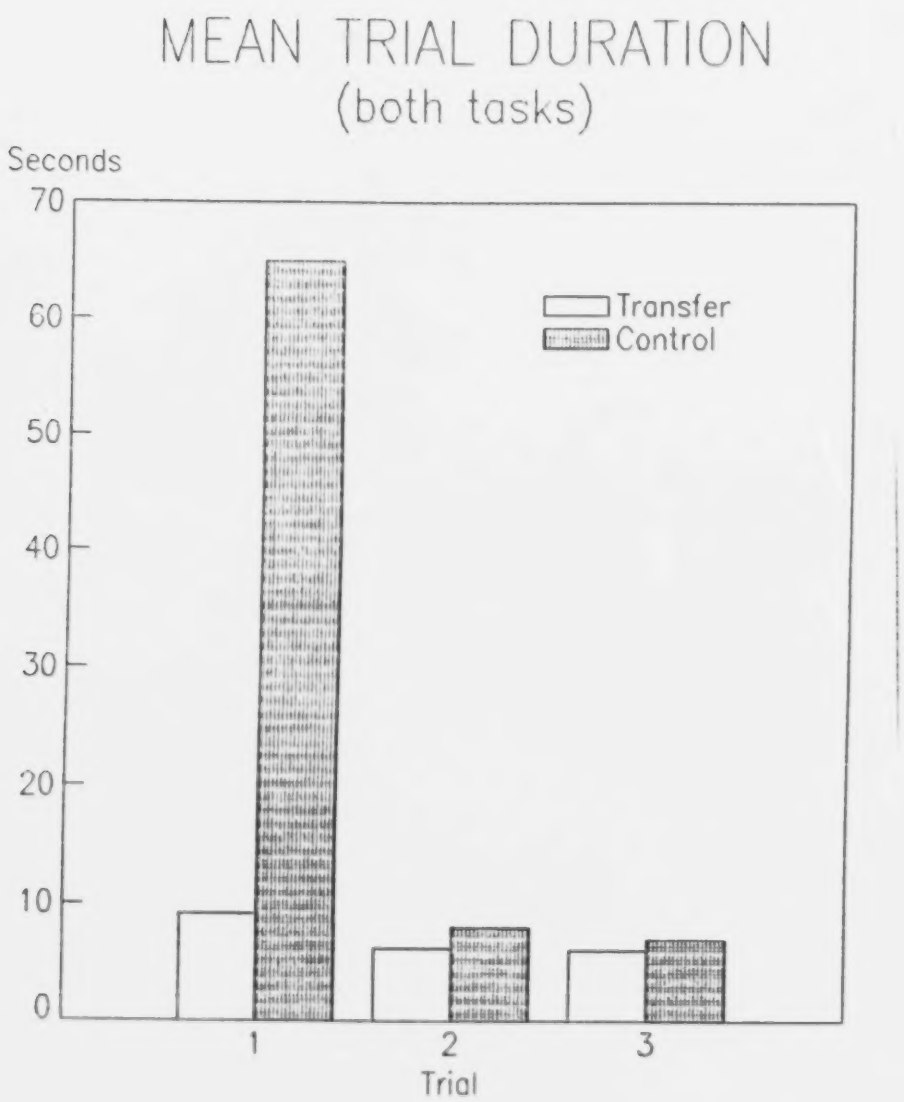

Fig. 4: Mean trial duration for children in transfer and control groups over three trials for both platform rotation tasks.